Clinical Epidemiology

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ORIGINAL RESEARCH

Lipid-Lowering Therapy Utilization and Dosage Among Patients with Acute Coronary Syndrome Events: A Retrospective Cohort from 12 Community Hospitals

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Introduction: Clinical practice guidelines recommend initiating a high-intensity LLT and continued monitoring of low-density lipoprotein cholesterol (LDL-C) following acute coronary syndrome (ACS). We used real-world data to describe LLT utilization after discharge and 1-year adherence. The reduction in LDL-C was also evaluated.

Methods: Data were extracted from electronic health records (EHRs) from 12 hospitals in a large community healthcare system in midwestern United States between 2013 and 2019. Data on eligible patients recently discharged with an ACS event were linked to pharmacy claims data to describe LLT fill rates and 1-year post-discharge adherence. Adherence was reported as the proportion of days covered ≥80%.

Results: Of the 10,589 eligible patients, 49% filled a high-intensity statin at discharge and only 36% were adherent at 1 year. The mean (SD) age was 66.1±13.3, 39.3% were females, 58.8% were Caucasian, and 53.0% had Medicare. There was a clear trend for greater fill rates at discharge among patients with higher LDL-C values than those with lower values (p<0.01). Key predictors of high-intensity (versus medium-intensity) LLT use within 21 days after an ACS event included ACS type (odds ratio [OR] 0.59; 95% confidence interval [CI] 0.52–0.67 for NSTEMI versus STEMI), age group (OR: 0.59; 95% CI: 0.48–0.72 for >75 years versus <65 years), and statin use before index ACS event (OR: 1.56; 95% CI: 1.23–1.88).

Conclusion: This real-world study found that despite recommendations in clinical practice guidelines, high-intensity LLT fill rates at discharge and 1-year adherence to LLT remain suboptimal. Clinical characteristics, including ACS type and LDL-C values, were strong predictors of filling and adherence to guideline-recommended therapy. Age, sex, and race/ethnicity disparities were observed in discharge fill rates and 1-year adherence. These results highlight the need for continued efforts at the patient and provider levels to improve LLT adherence among ACS patients.

Keywords: lipid-lowering therapy, high-intensity statin, acute coronary syndrome, real-world data, prescribing, adherence

Introduction

Acute coronary syndrome (ACS), consisting of ST-elevation myocardial infarction (STEMI), non-ST-elevation myocardial infarction (NSTEMI), and unstable angina (UA), is commonly associated with a high risk of subsequent cardiovascular events and mortality beyond the first year after the event.[1,2] Post-event lipid-lowering therapy (LLT), including statins, ezetimibe, and proprotein convertase subtilisin/kexin type 9 inhibitor monoclonal antibodies (PCSK9i mAbs), is a vital part of secondary prevention treatment.[3–5] A meta-analysis of randomized controlled trials showed that high-intensity statin therapy reduced low-density lipoprotein cholesterol (LDL-C) levels by ≥50% compared with an untreated

Received: 16 January 2023
Accepted: 11 April 2023
Published: 4 May 2023

baseline. The review also indicated a 15%-19% reduction in subsequent events and up to 20% reduction in mortality due to coronary artery disease.[6] The 2013 American College of Cardiology (ACC) and the American Heart Association (AHA) cholesterol treatment guideline recommended high-intensity statins and LDL-C monitoring for most patients with ACS.[7] The 2018 AHA/ACC Multisociety cholesterol guideline continues to recommend high-intensity statins as the mainstay of treatment and emphasize the importance of continued monitoring of LDL-C levels and intensification of current LLT and/or additions of PCSK9i mAbs if LDL-C remains above 1.81 mmol/L after ACS events.[8]

Despite recommendations in clinical practice guidelines, continued underuse and underdosing of LLT after an ACS event are reported in the literature based on data from randomized controlled trials and clinical registries.[9–11] Reasons for underutilization and non-adherence to LLT are complex and often associated with barriers at the patient, care team, and healthcare system levels. This study aimed to quantify utilization patterns of LLT after ACS events and to identify potential predictors of underutilization of LLT in a large and diverse healthcare system in the United States (US).

Patients and Methods

Study Population and Data Sources

This was a retrospective cohort study of data extracted from electronic health records (EHRs) of adult patients from Advocate Aurora Health (AAH). AAH is a large, integrated community-based healthcare system spanning Illinois and Wisconsin. For this study, data was extracted from patients admitted to any of AAH's 12 hospitals located in Illinois. Patients 18 years and older, discharged from one of the 12 hospitals between 1/1/2013 and 8/31/2019 with a primary diagnosis of the first ACS event (ie, the index event) were included in the study. ACS was defined as STEMI, NSTEMI, or UA using the International Classification of Diseases, Ninth Revision, and Tenth Revision (ICD-9 and ICD-10) codes (see Appendix I for patient flowchart and ICD codes used). The date of the patient's discharge was assigned as the index date. Eligible patients who had at least one additional encounter documented in the EHR after their index event were followed up for 1 year from the index date. Patients with the following conditions were excluded: deceased during the hospital stay, discharged to hospice, and/or with an unknown type of ACS. EHR data were linked with pharmacy claims data (IQVIA's Longitudinal Prescription Claims Data [LRx]) to provide information on medication fill rates that were not available in the EHR. The LRx database is a nationally representative database that contains longitudinal data collected directly from pharmacy suppliers for adjudicated dispensed prescriptions sourced from retail (92% coverage), mail (62% coverage of traditional and specialty mail order), and long-term care (76% coverage) amounting to over 150 million unique patients and over 1 million unique prescribers, with data updated monthly. Post-index LDL-C values from the AAH EHR were supplemented by Prognos laboratory data. Prognos laboratory data are sourced from multiple national laboratories, regional laboratories, and inpatient facilities. These data represent over 160 million patients, 300,000 physicians, and over 9 billion laboratory result records. The protocol was reviewed and considered exempt under category 4 for which consent is not required, no greater than minimal risk, and received a HIPAA waiver by the Advocate Aurora Health IRB and was in compliance with the Declaration of Helsinki.

Study Variables and Outcome Definitions

Patient demographic and clinical characteristics were extracted from the EHR. Patient's age was calculated using the date of birth at the time of the index hospital admission. Race and ethnicity were identified from self-reported data in the EHR. Comorbid conditions were extracted from the EHR using ICD-9 and ICD-10 codes. LDL-C values collected at the index visit were extracted from the EHR and included the first available measurement during the hospital stay. LDL-C values at 1 year were extracted from the laboratory information linked to IQVIA's data.

Medication utilization data were extracted from LRx. LLTs were grouped into high-intensity statins, other high-intensity-LLT, medium-intensity LLT, low-intensity LLT, other LLT, and no LLT (Appendix II).[12] Due to the small sample size of patients using other high-intensity LLT, patients using high-intensity statins and other high-intensity LLT were combined under one category called high-intensity LLT, in some analyses. Patterns of LLT utilization were described at the class/intensity level and included dosing reduction, escalation, augmentation, discontinuation, and/or switching. For example, if a patient switched between two types of statins (eg, simvastatin to pravastatin) but both statins

were of the same intensity, the switch was not considered a change; however, if the switch between two types of statins resulted in the use of a different intensity of statin therapy, the switch was classified as either a reduction or an escalation, whichever was applicable.

LLT utilization was captured over three predefined periods: (i) pre-index, where LLT use was defined as LLT filled during the 360 days before the index visit. If more than one LLT was observed during the pre-index period, the prescription claim closest to the index date was used. (ii) at index, where LLT use at index (ie, discharge), was defined as at least one LLT fill within 21 days after discharge; and (iii) post-index, where LLT use was defined as LLT on hand at day 360 from the index date. Adherence within the 360-day post-index period was reported as the proportion of days covered (PDC) ≥80%, which was defined as the total number of days covered by filled medication divided by the duration of the follow-up period (in days) specific to each patient. PDC was reported at the medication class level.

Clinical practice guidelines recommend antiplatelet therapy (APT) and beta-blockers (BB) for patients with an ACS event. Prescription fills were collected at index and 1-year post-index for APT and BB using LRx in addition to LLTs to evaluate if utilization patterns were similar across different ACS guideline-directed medical therapy (Appendix II).

Statistical Analysis

Means and standard deviations were reported for continuous variables. Absolute numbers (n) and percentages were reported for categorical variables. Chi-square tests, Student's t-tests, or Mann–Whitney tests were used as appropriate. Changes in LLT utilization were visualized using a Sankey diagram and categorized into the three periods mentioned earlier. Multinomial logistic regression was used to predict the determinants of filling high-intensity LLT during the 21-day at-index period where four levels of LLT use, as the dependent variable, were considered simultaneously with several independent variables. The four levels of LLT in the model were (i) other or no LLT, (ii) low-intensity LLT, (iii) medium-intensity LLT, (iv) and high-intensity LLT (reference). Independent variables included pre-index statin use; payer type associated with LLT filled; specialty of the provider who ordered the LLT; hospital teaching status; ACS event type; age group; gender; race/ethnicity; and the following pre-index comorbid conditions of interest: diabetes, hypertension, current smoker, stroke, chronic kidney disease (any stage), and any revascularization procedure.

Results

Patient Characteristics

A total of 10,589 patients were included in the analysis. The mean (standard deviation [SD]) age was 66.1 ± 13.3 years, 39.3% were females, 58.8% were Caucasian, and 53.0% had Medicare. Hypertension was the most common comorbidity (81.7%), followed by hyperlipidemia (54.7%) and coronary artery disease (53.3%). A total of 24.7% were ever smokers. LDL-C measured during the hospital stay was available for 5467 patients (51.6% of patients included in the analysis), with a mean (SD) of 2.51± 1.02 mmol/L; 25.0% had LDL-C <1.81 mmol/L (Table 1).

Table 1 Patient Demographic and Clinical Characteristics

	All ACS N=10,589	STEMI N=2791	NSTEMI N=7316	UA N=466
Age (years), mean (SD)	66.1 ± 13.3	63.2 ± 12.3	67.5 ± 13.4	61.8 ± 13.4
<65 years	4925 (46.5%)	1555 (55.7%)	3079 (42.1%)	282 (60.5%)
65–75 years	2707 (25.6%)	722 (25.9%)	1889 (25.8%)	92 (19.7%)
>75 years	2957 (27.9%)	514 (18.4%)	2348 (32.1%)	92 (19.7%)
Female, n (%)	4165 (39.3%)	867 (31.1%)	3046 (41.6%)	247 (53.0%)
Race/Ethnicity, n (%)				
Caucasian	6223 (58.8%)	1822 (65.3%)	4166 (56.9%)	223 (47.9%)
African American	1932 (18.2%)	316 (11.3%)	1472 (20.1%)	143 (30.7%)
Hispanic/Latino	697 (6.6%)	169 (6.1%)	487 (6.7%)	41 (8.8%)
Other/Unknown	1737 (16.4%)	484 (17.3%)	1191 (16.3%)	59 (12.7%)

(*Continued*)

Table 1 (Continued).

	All ACS N=10,589	STEMI N=2791	NSTEMI N=7316	UA N=466
Payer type, n (%)				
Commercial	3813 (36.0%)	1271 (45.5%)	2347 (32.1%)	186 (39.9%)
Medicare	5607 (53.0%)	1198 (42.9%)	4202 (57.5%)	200 (42.9%)
Medicaid	1054 (10.0%)	274 (9.8%)	704 (9.6%)	76 (16.3%)
Uninsured/self-pay	112 (1.1%)	48 (1.7%)	60 (0.8%)	4 (0.9%)
Comorbidities (top 5), n (%)				
Hypertension	8650 (81.7%)	2098 (75.2%)	6158 (84.2%)	381 (81.8%)
Hyperlipidemia	5795 (54.7%)	1419 (50.8%)	4118 (56.3%)	251 (53.9%)
Coronary artery disease	5641 (53.3%)	1361 (48.8%)	3818 (52.2%)	459 (98.5%)
Diabetes	2780 (26.3%)	560 (20.1%)	2080 (28.4%)	140 (30.0%)
Stroke	808 (7.6%)	146 (5.2%)	644 (8.8%)	18 (3.9%)
Ever smoker, n (%)	2618 (24.7%)	840 (30.1%)	1677 (22.9%)	96 (20.6%)
LDL-C at index visit, mean (SD)[a]	97.2± 39.5	102.1 ± 38.7	95.1 ± 39.9	97.5 ± 36.0
LDL-C <1.81 mmol/L, n (%)	1366 (25.0%)	319 (20.0%)	1013 (27.3%)	33 (20.8%)

Notes: Each category may not add up to the total sample size because patients with missing data from each descriptive variable were excluded. [a]Data on LDL-C were available for 5467 patients only.
Abbreviations: ACS, acute coronary syndrome; LDL-C, low-density lipoprotein cholesterol; NSTEMI, non-ST-segment elevation myocardial infarction; SD, standard deviation; STEMI, ST-segment elevation myocardial infarction; UA, unstable angina.

LLT Utilization

Figure 1 presents an overall visualization of LLT utilization over three periods of time. Before the index date, 46% of patients filled any LLT. During the index period, 71% filled any LLT (49% filled a high-intensity statin and <1% filled other high-intensity LLT) During the post-index period, 58% filled any LLT, and the use of high-intensity statins decreased to 36%.

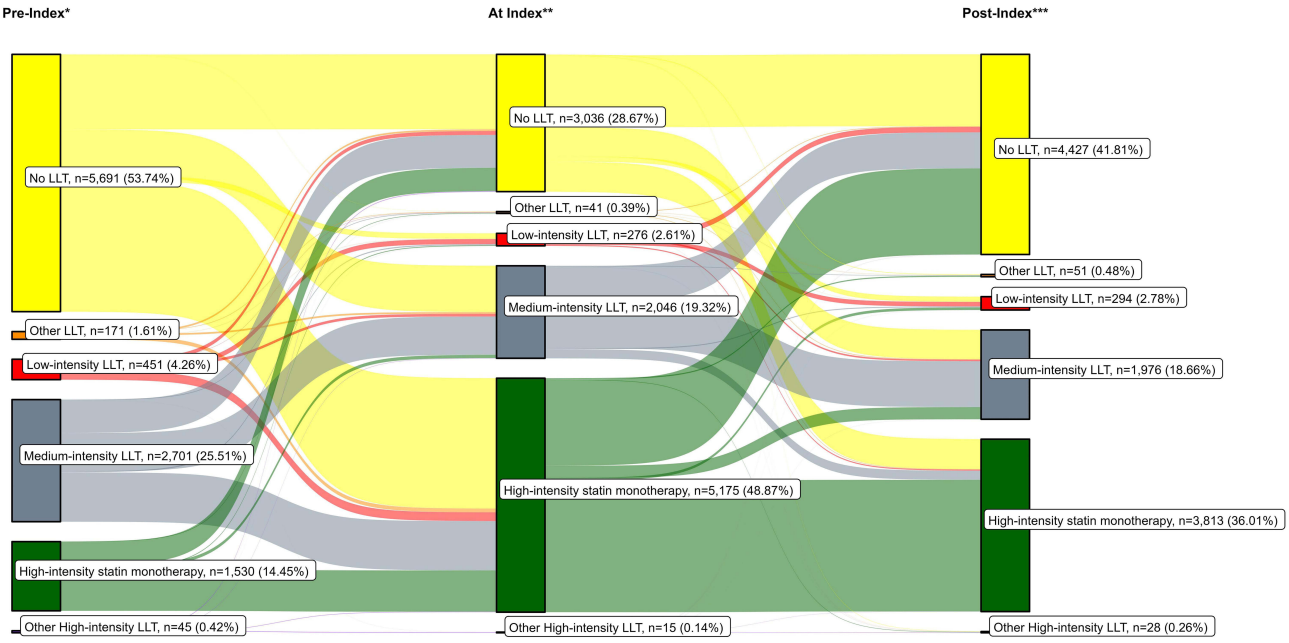

Figure 1 Sankey diagram of LLT utilization over three periods of time. *Pre-index LLT utilization: LLT use on hand 360 days before the index date. **At-index LLT utilization: filled LLT prescription within 21 days of the index date. ***Post-index LLT utilization: LLT use on hand within 360 days from the index date.
Abbreviation: LLT, lipid-lowering therapy.

Time Trends in High-Intensity Statin Utilization

Given the multiyear data available for this analysis, it was possible to evaluate time trends in LLT fill rates. Overall, there was an increase in high-intensity statin 21-day post-discharge fill rates from 31% in 2013 to 71% in 2019 ($p<0.01$; Figure 2A). The 1-year adherence increased from 17% in 2013 to 31% in 2017 and then dropped back down to 25% in 2019 ($p<0.01$; Figure 2A).

Determinants in 21-Day High-Intensity Statin Use and 1-Year Adherence

Overall, there were differences in 21-day high-intensity statin fill rates ($p<0.01$) and 1-year adherence ($p<0.01$) across four ethnic groups (Caucasian 52%, 29%; African American 43%, 18%; Hispanic/Latino 54%, 25%, and Other/Null/Decline 45%, 25%; 21-day fill rate and 1-year adherence respectively; Figure 2B). Differences were also evaluated by LDL-C values collected during the hospital stay (available for 5467 patients). The 21-day high-intensity statin fill rates increased with greater LDL-C values (overall $p<0.01$; Figure 2C). The 1-year adherence increased with increasing baseline LDL-C values ($p=0.01$, Figure 2C).

We identified several demographic and clinical characteristics that had significant impacts on the use of high-intensity LLT. Table 2 shows the results of the fully adjusted multinomial logistic regression model. For example, patients using statins before the index ACS event were 56% more likely to fill high-intensity LLT compared with medium-intensity LLT (OR=1.56, 95% confidence interval [CI] 1.23–1.98). Patients receiving care at teaching hospitals and males had increased odds of filling high-intensity LLT, while other/unknown provider specialty, NSTEMI or UA (compared with STEMI), and age >75 years (compared with <65 years) had decreased odds of filling high-intensity LLT.

We identified patients filling a high-intensity statin during the index period, and who also filled an APT and/or a BB. Patients with a STEMI event had the highest rate of 1 year-adherence to a high-intensity statin, APT, or BB (58.7%, 61.2%, and 56.8%, respectively), followed by those with NSTEMI events (51.4%, 44.5%, and 48.5%, respectively) and finally those with UA events (41.3%, 23.9%, and 35.2%, respectively) (Figure 3).

LDL-C Values at Discharge and One Year

LDL-C values were available for some patients at discharge (n = 5467) and at 1 year after the index date (n = 722; Table 3), allowing the evaluation of LDL-C goals reached and change in LDL-C between two points of time. The mean (SD) LDL-C values dropped from 2.64 ± 1.04 mmol/L at discharge to 2.00± 0.89 mmol/L after 1 year, yet 50% of 361 patients did not reach the LDL-C goal of ≤1.81 mmol/L (Table 3). Results presented in Figure 4 indicate that the greatest reduction in LDL-C values over 1 year after the index event (ie, 34% decrease from 2.66 mmol/L to 1.76 mmol/L) was among patients who filled a high-intensity statin at discharge and were also adherent with these medications over 1 year. On the contrary, patients who did not adhere to a high-intensity statin had a smaller decrease (21%) from 2.69 mmol/L to 2.12 mmol/L. Results of this subgroup analysis should be interpreted with caution as population differences (different types of ACS) were observed between patients who had LDL-C values and those who did not (Appendix III).

Discussion

Despite recommendations in clinical practice guidelines to prescribe high-intensity statins to patients with ACS, results from this retrospective cohort study indicated that only half of the patients filled such prescriptions within 21 days of discharge.[12] Further, over a 1-year follow-up period, only 8.5% of patients obtained a follow-up lipid panel, only one-third of patients adhered to LLT, and half of the patients who had their follow-up LDL-C measured did not reach the LDL-C goal of ≤1.81 mmol/L. Results from this analysis suggest that lipid management was suboptimal during 2013 to 2019, as seen by the substantial portion of patients who either did not receive guideline-recommended LLT or for whom statins were not enough to bring their LDL-C below guideline-recommended levels. Consistent with results from clinical trials,[13] this real-world data confirm that the subset of patients who filled a high-intensity LLT within 21 days as recommended in clinical practice guidelines and those who adhered to the treatment over 1 year had the greatest reduction in LDL-C values. Intensive LLT leads to lower LDL-C levels and a lower risk of subsequent events. Intensive lipid-lowering can be achieved by using high-intensity statins or statins intensified with PCSK9i mAbs to reach recommended LDL-C levels.[12]

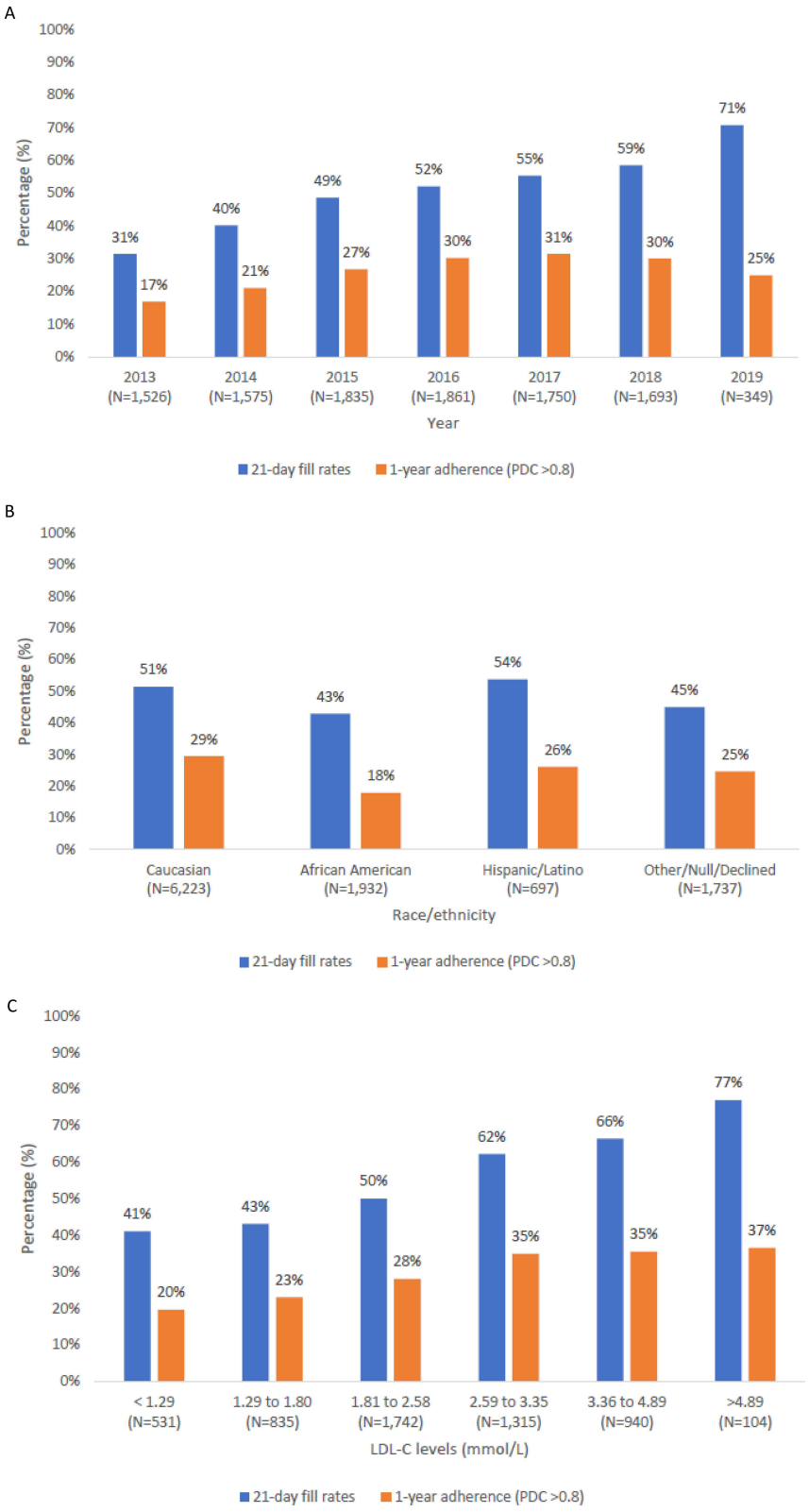

Figure 2 (**A**) High-intensity statin 21-day fill rates and 1-year adherence time trends (N=10,589). Overall, across years: p<0.01 for 21-day fill rates, and p<0.01 for 1-year adherence. (**B**) High-intensity statin 21-day fill rates and 1-year adherence- by race/ethnicity (N=10,589). Overall, across race/ethnic groups: p<0.01 for 21-day fill rates, and p<0.01 for 1-year adherence. (**C**) High-intensity statin 21-day fill rates and 1-year adherence- by LDL-C measured during hospital stay (N=5467). Overall, across LDL-C levels: *p*<0.01 for 21-day fill rates, and *p*=0.01 for 1-year adherence.

Abbreviations: LDL-C, Low-density lipoprotein cholesterol; LLT, Lipid-lowering therapy.

Table 2 Association Between Patient Characteristics and High-Intensity Statins/Other High Intensity LLT 21-Day Fill Rate (N=9522)

Independent Variable	High-Intensity LLT vs Medium-Intensity LLT		High-Intensity LLT vs Low-Intensity LLT		High-Intensity LLT vs Other LLT or No LLT	
	N	Odds Ratio (95% CI)	N	Odds Ratio (95% CI)	N	Odds Ratio (95% CI)
Pre-index statin use (reference= no)						
Pre-index statin use	93	1.56 (1.23–1.98)	15	1.27 (0.74 2.17)	122	1.12 (0.90–1.40)
Index payer type (reference= commercial)						
Medicare	1158	0.88 (0.73–1.06)	187	0.61 (0.38–0.97)	1338	0.54 (0.44–0.65)
Medicaid	180	0.99 (0.81–1.21)	25	0.63 (0.38–1.02)	165	0.85 (0.69–1.05)
Uninsured/Self-pay	12	1.76 (0.94–3.30)	3	0.53 (0.16–1.77)	16	0.83 (0.47–1.46)
Provider specialty (reference= PCP [family/internal medicine])						
Cardiologist	403	1.06 (0.92–1.21)	63	0.75 (0.55–1.03)	374	0.98 (0.85–1.13)
Other/unknown	345	0.96 (0.83–1.11)	55	0.72 (0.52–0.99)	388	0.83 (0.72–0.96)
Facility teaching status (reference= non-teaching)						
Teaching facility	591	1.87 (1.67–2.10)	95	1.49 (1.14–1.93)	730	1.43 (1.27–1.60)
ACS event type (reference= STEMI)						
NSTEMI	1510	0.59 (0.52–0.67)	229	0.32 (0.22–0.46)	1532	0.44 (0.38–0.51)
Unstable Angina	80	0.24 (0.18–0.34)	12	0.12 (0.06–0.24)	186	0.07 (0.05–0.10)
Age group (reference <65 years)						
65–75 years	492	0.96 (0.80–1.16)	72	0.82 (0.52–1.31)	520	1.14 (0.94–1.38)
>75 years	687	0.59 (0.48–0.72)	117	0.49 (0.30–0.80)	776	0.73 (0.59–0.90)
Gender (reference= female)						
Male	1158	1.25 (1.12–1.40)	138	1.55 (1.20–2.00)	1091	1.31 (1.17–1.47)
Race/ethnicity (reference= Caucasian)						
African American	385	0.86 (0.74–1.00)	52	1.01 (0.72–1.42)	403	0.97 (0.84–1.13)
Hispanic/Latino	109	1.10 (0.88–1.39)	15	1.22 (0.70–2.12)	130	1.08 (0.86–1.36)
Other/Null/Declined	403	0.71 (0.62–0.82)	44	0.89 (0.63–1.26)	327	0.83 (0.71–0.97)
Comorbid conditions of interest (reference= no)						
Diabetes	567	0.77 (0.68–0.88)	73	0.90 (0.67–1.20)	687	0.67 (0.59–0.76)
Hypertension	1690	0.97 (0.84–1.12)	228	1.11 (0.80–1.56)	1758	0.84 (0.71–0.98)
Smoker	476	1.00 (0.88–1.14)	54	1.10 (0.80–1.52)	412	1.09 (0.95–1.25)
Stroke	173	0.83 (0.68–1.02)	23	0.99 (0.63–1.56)	203	0.83 (0.68–1.02)
Chronic kidney disease (stage 1–7)	473	0.89 (0.77–1.02)	85	0.67 (0.51–0.90)	644	0.64 (0.56–0.73)
Revascularization (any)	27	1.34 (0.85–2.10)	4	1.31 (0.47–3.64)	51	0.82 (0.56–1.20)

Abbreviations: ACS, acute coronary syndrome; CI, confidence intervals; LLT, Lipid lowering therapy; NSTEMI, non-ST-segment elevation myocardial infarction; OR, odds ratio; STEMI, ST-segment elevation myocardial infarction; UA, unstable angina.

Our results extend the evidence that addresses current literature gaps in guideline-concordant utilization of high-intensity statins among ACS patients.[14–16] High-intensity LLT fill rates within 21 days of the event seems to be influenced by patients' clinical characteristics, despite clinical practice guidelines recommending appropriate LLT to all patients with ACS. For example, patients with STEMI were most likely to fill a high-intensity LLT than those with NSTEMI and UA. Patients with higher LDL-C values during hospital stays were more likely to fill a high-intensity LLT. Older patients and females were less likely to fill a high-intensity LLT. Further investigation and increased efforts are warranted to reduce disparities in ACS management. Increased awareness of the benefits of high-intensity LLT is needed to reinforce better post-discharge lipid and ACS management among women.[17]

The observed high-intensity statin 21-day fill rate and 1-year adherence in Black/African American patients were numerically lower than those in Caucasian patients. This likely contributes to the observed racial and ethnic disparities in clinical outcomes and mortality among patients with ACS.[18–22] However, these associations were attenuated after adjusting for other risk factors using multinomial logistic regression.

Results from time-trend analysis show that concordance with clinical practice guidelines increased between 2013 and 2019, although it remained suboptimal in 2019. This is consistent with earlier findings indicating an increase in high-intensity

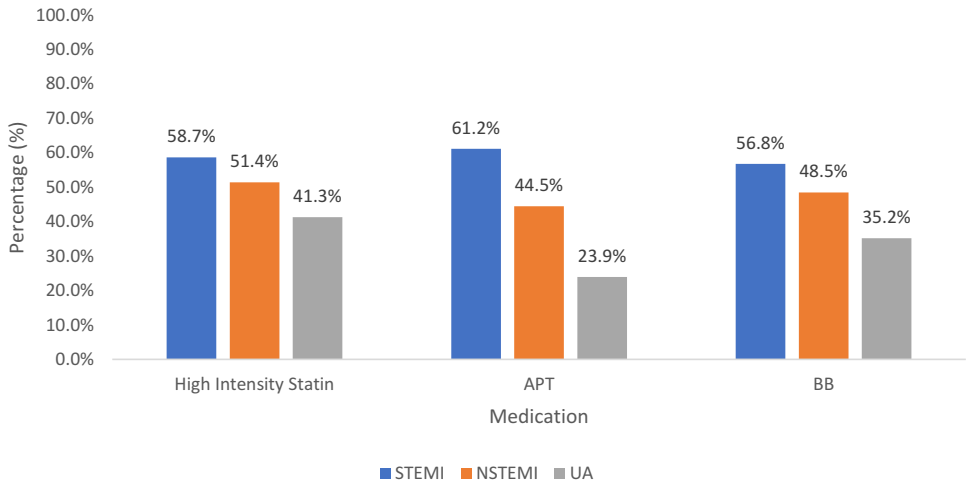

Figure 3 1-year adherence for high-intensity statins, antiplatelet therapy (APT), and beta blockers (BB).
Abbreviations: APT, Antiplatelet therapy; BB, Beta-blockers NSTEMI, non-ST-segment elevation myocardial infarction; STEMI, ST-segment elevation myocardial infarction; UA, unstable angina.

statin use in the US over time.[16] Despite improvement in LLT fill rates over the years, little to no change was observed in post-index 1-year adherence with LLT. This highlights the need to accelerate efforts and strategies to improve both LLT initiation and adherence. Our analysis only included information on LLT fill rates. Information about LLT being prescribed against LLT being filled was not reliable, and thus analysis was not performed. Further investigation is required to understand provider barriers to prescribing high-intensity LLT and patient barriers to filling in LLT at the time of discharge and beyond.

A substantial portion of patients with high-intensity statins during the index period discontinued by day 360. We did not explore the reasons for discontinuation in this study. A fear of side effects and perceived side effects have been reported as the common reasons to discontinue statins.[23] Perceived side effects from statins have been reported to be as high as 50% although side effects reported in clinical trials are much lower.[23] Efforts on the providers' end to address perceived side effects are required and shared decision-making strategies should be developed to identify and recommend alternative LLT instead of complete discontinuation of high-intensity LLT.[24]

This study is among the few that links and evaluates EHR data to pharmacy claims data, providing a comprehensive overview of the patient's clinical diagnoses, outcomes, LLT utilization, and patient adherence to LLT from a large integrated community healthcare system with a diverse patient population in terms of clinical and demographic characteristics. However, the results of this study should be interpreted considering several possible limitations. First,

Table 3 LDL-C Levels at Discharge and 1 Year Following the ACS Discharge

LDL-C (mmol/L)	ALL ACS	STEMI	NSTEMI	UA
LDL-C at discharge Mean (SD)	N = 4242 102.2 ± 40.1	N = 1393 105.7 ± 40.2	N = 2758 98.7 ± 39.3	N = 86 124.3 ± 71.5
LDL-C at 1 year[a] Mean (SD) LDL-C reduction ≥50%, n (%) LDL-C <1.29 mmol/L, n (%) LDL-C ≤1.81 mmol/L, n (%) LDL-C ≤2.59 mmol/L, n (%)	N = 361 77.3 ± 34.6 43 (11.9%) 65 (18.0%) 179 (49.6%) 297 (82.3%)	N = 146 75.2 ± 29.3 22 (15.1%) 19 (13.0%) 80 (54.8%) 121 (82.9%)	N = 209 77.9 ± 37.8 21 (10.0%) 46 (22.0%) 98 (46.9%) 173 (82.8%)	N = 6 104.3 ± 31.4 0 (0.0%) 0 (0.0%) 1 (16.7%) 3 (50.0%)

Notes: [a]The LDL-C value closest to the end of 360 days after ACS discharge (within 90 days before or after the end of follow-up, whichever available) was used. The percentage reduction in LDL-C was assessed using the difference in LDL-C at discharge and LDL-C at 1 year after ACS discharge.
Abbreviations: ACS, acute coronary syndrome; LDL-C, low-density lipoprotein cholesterol, NSTEMI: non-ST-segment elevation myocardial infarction; SD, standard deviation; STEMI, ST-segment elevation myocardial infarction; UA, unstable angina.

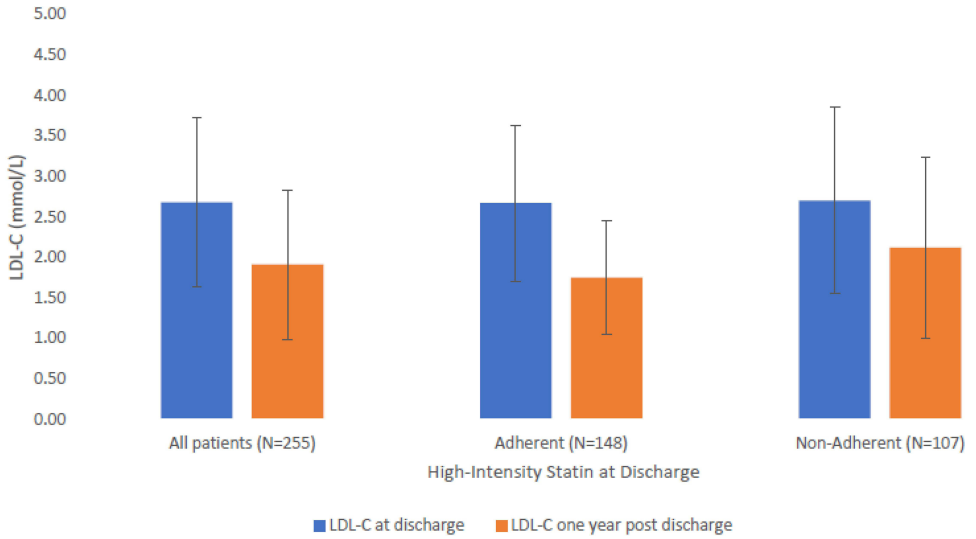

Figure 4 Relationship between 1-year adherence to high-intensity statins and decrease in LDL-C values over 1-year. The LDL-C value closest to the end of 360 days post ACS discharge (within 90 days before or after the end of follow-up, whichever available) was used. The % reduction in LDL-C was assessed using the difference in LDL-C at discharge and LDL-C at one year post ACS discharge. LDL-C measures at both time points were available for 361 patients. Adherence is defined as the proportion of days covered (PDC) ≥0.80.
Abbreviation: LDL-C, Low-density lipoprotein cholesterol.

although the study included a large and diverse patient population, data were limited to a single healthcare system, and results may not be generalizable beyond that healthcare system. Patients receiving care in other healthcare systems can only be assumed to be censored, which is a common limitation of studies conducted in a single healthcare system. Second, we used prescription fills within 21 days of an event as a proxy to provider prescription patterns. It is possible that a patient was prescribed LLT but due to access or other barriers did not fill the prescription within 21 days. Third, as in any observational study, evaluating predictors may be confounded by unmeasured variables or biases. Fourth, we were limited to subsets of patients with LDL-C values during hospital stays and at 1-year post-index. Results based on LDL-C should be interpreted with caution, although our results are consistent with findings from other studies. Others have reported poor rates of follow up lipid testing after the index event and prescription of LLT, despite guideline recommendations.[25]

Conclusions

In conclusion, EHR data from a large and diverse midwestern healthcare system linked to pharmacy claims data indicated large gaps in LLT treatment and lipid management after discharge for ACS. Only half of the patients with an ACS event filled a high-intensity statin within 21 days, and only one-third adhered to treatment over 1 year. Clinical characteristics including type of ACS (STEMI) and high LDL-C levels were strong predictors of receiving a high-intensity LLT. Disparities in age, sex, and race/ethnicity were observed in LLT utilization. Results from this study highlight opportunities to improve LLT guideline–concordant care and suggest the need for continued efforts to address barriers at the patient, provider, and even healthcare system levels to improve LLT treatment and lipid management, minimize the risk of ACS events, and address associated disparities to achieve a more equitable healthcare.

Data Sharing Statement

Data used in this study were derived from the AAH EHR and IQVIA's Longitudinal Prescription Claims Data.

Acknowledgments

Editorial support was provided by Qais Al-Hadid (Amgen) and Sangeeta P.C. (Cactus Communications).

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

This study was sponsored by Amgen Inc. The sponsor contributed to the study design and interpretation of data.

Disclosure

RK, NG, and NS are employees of Advocate Aurora Health and have nothing to disclose. AR is an employee at Cheyenne Regional Medical Group and has nothing to disclose. YL was an employee of Advocate Aurora Health at the time of study initiation and is now an employee of IQVIA and has nothing to disclose. CBM and RLW are employees of IQVIA, which received funding from Amgen to conduct this work. HX was an employee of IQVIA at the time of study initiation and is now an employee of Teva Pharmaceutical Industries Ltd. EJY and BK are employees of Amgen and hold Amgen stock. Neal Sawlani reports personal fees from Edwards Lifesciences, personal fees from Boston Scientific, personal fees from Biotronik, outside the submitted work. The authors report no other conflicts of interest in this work.

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